Ionization Profile Monitor Magnet

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There were investigated two options of IPM magnet design: electromagnet and permanent magnet. Each of them has pros and cons and can be designed in agreement with the specification. The preliminary analysis (D.Harding) of beam distortion and following discussion confirmed the possibility of using only two magnets. Both magnets should produce zero integral field and it will be automatically made if both magnets will have a common magnetic flux and symmetry (see Fig.1). The common magnetic flux and core eliminate magnet back leg, reduce fringing fields, weight and simplify the magnet calibration. Second air gap, which is identical to the first one, can be used for a second (spare) detector installation to improve resolution.

Electromagnet version

Magnet parameters:

Main air gaps	6.3” (160 mm)
Length	0.87 m
Main field	0.2 T
Current	257 A
Coil number of turns	64
Number of coils	4
Number of water circuits	4
Coil resistance	0.018 Ohm
Copper conductor	8 mm x 8 mm
Cooling hole diameter	4 mm
Total power	4.8 kW
Voltage	20 V
Water flow	0.7 l/min
Water pressure drop	2 atm
Water temperature rise	24 ºC

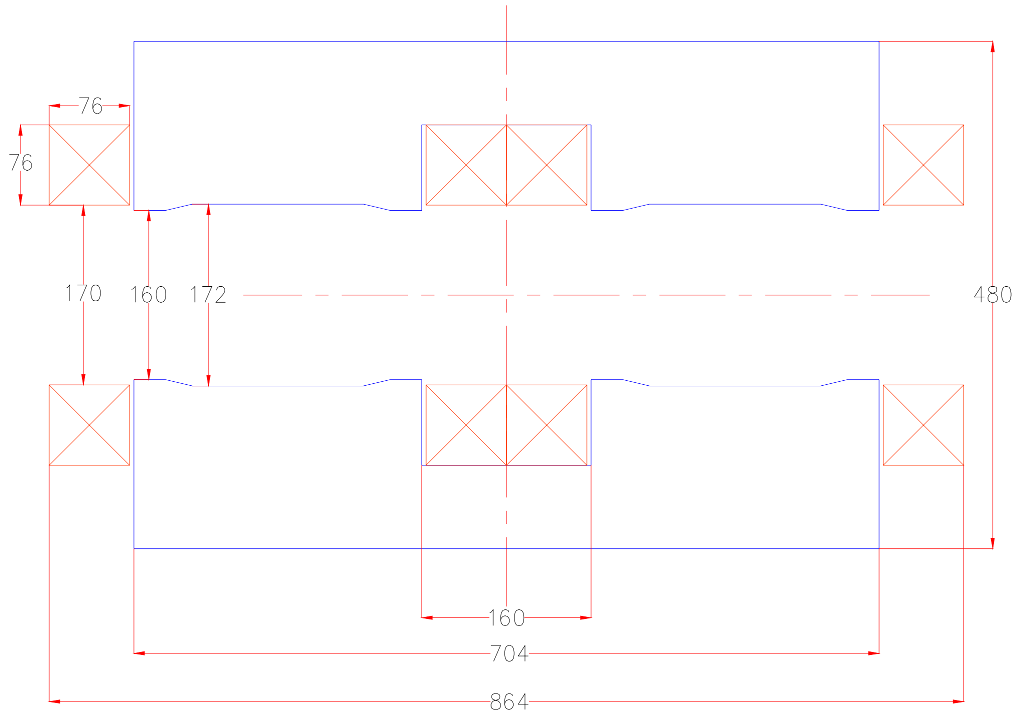

Fig. 1. Magnet cross-section

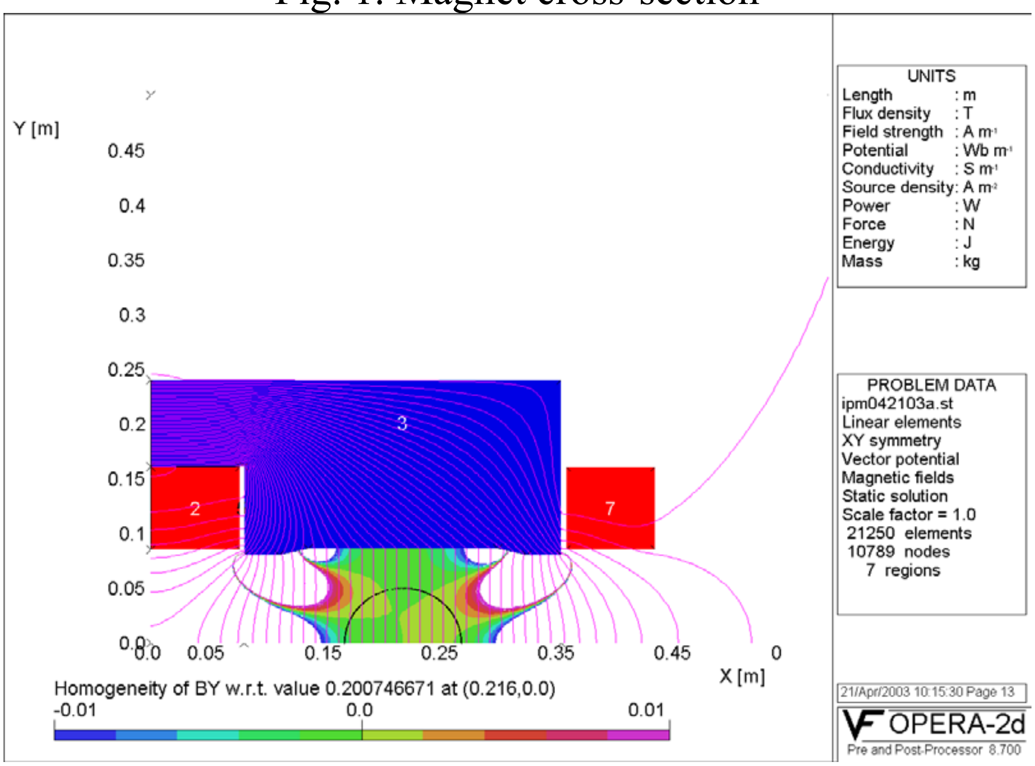

Fig. 2. Field distribution along the beam

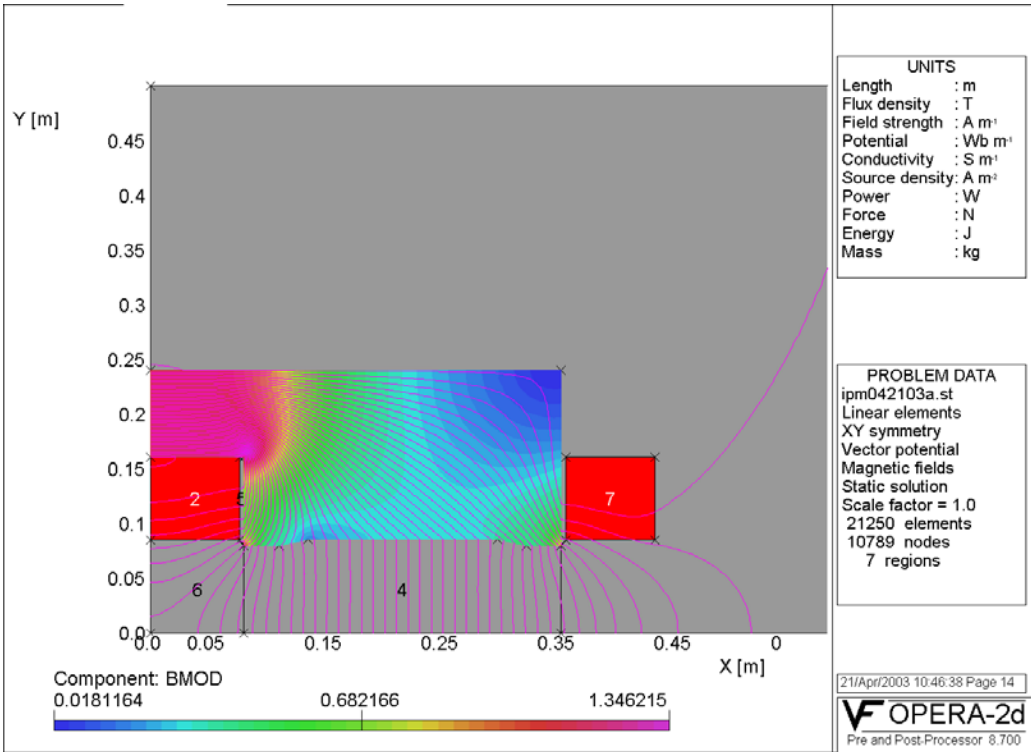

Fig. 3. Field distribution in the core

Permanent magnet version

Permanent magnet geometry is close to the geometry of electromagnet. Permanent magnet bricks having dimensions ½" x 1" x 2" assembled with 4 magnet poles. Quantity of permanent magnet material is not optimized now. Magnetic field inside air gap is formed by ferromagnetic pole tips, which totally eliminate the effect of possible deviation in magnetizations between bricks. The good field area is the same as in an electromagnet. Because both air gaps are coupled through the common magnetic flux, there is no temperature dependence on integrated field, which should be zero.

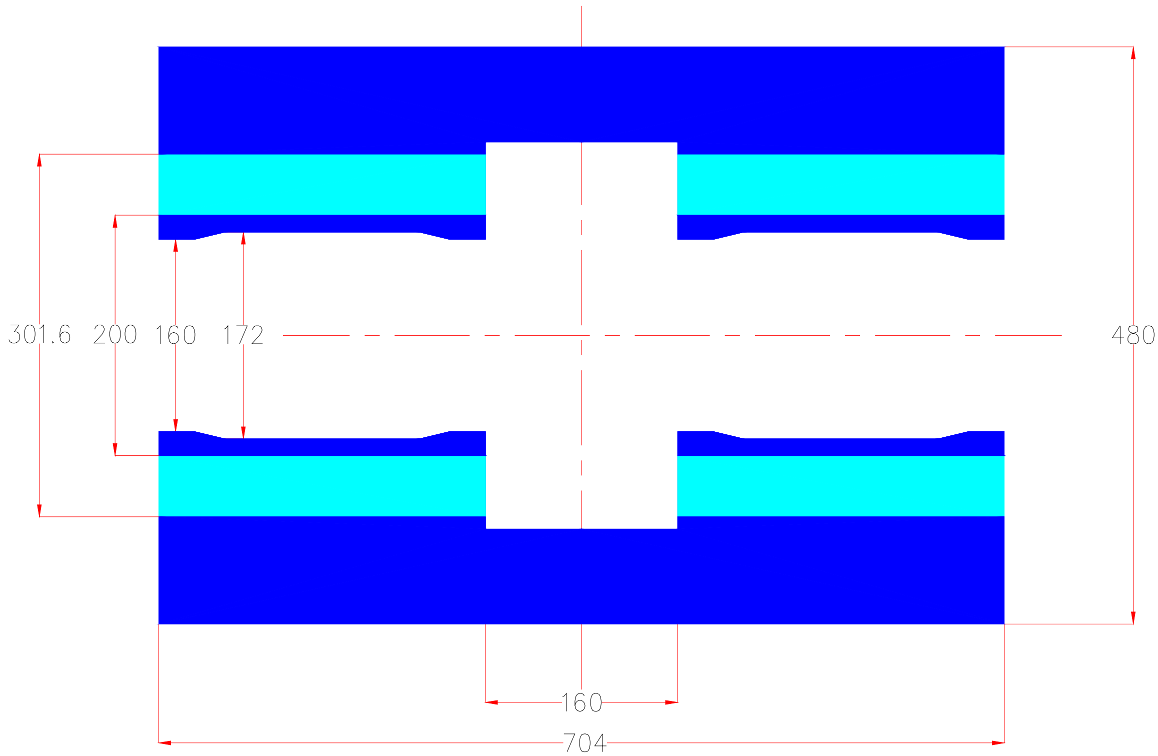

Fig. 4 Permanent magnet cross-section

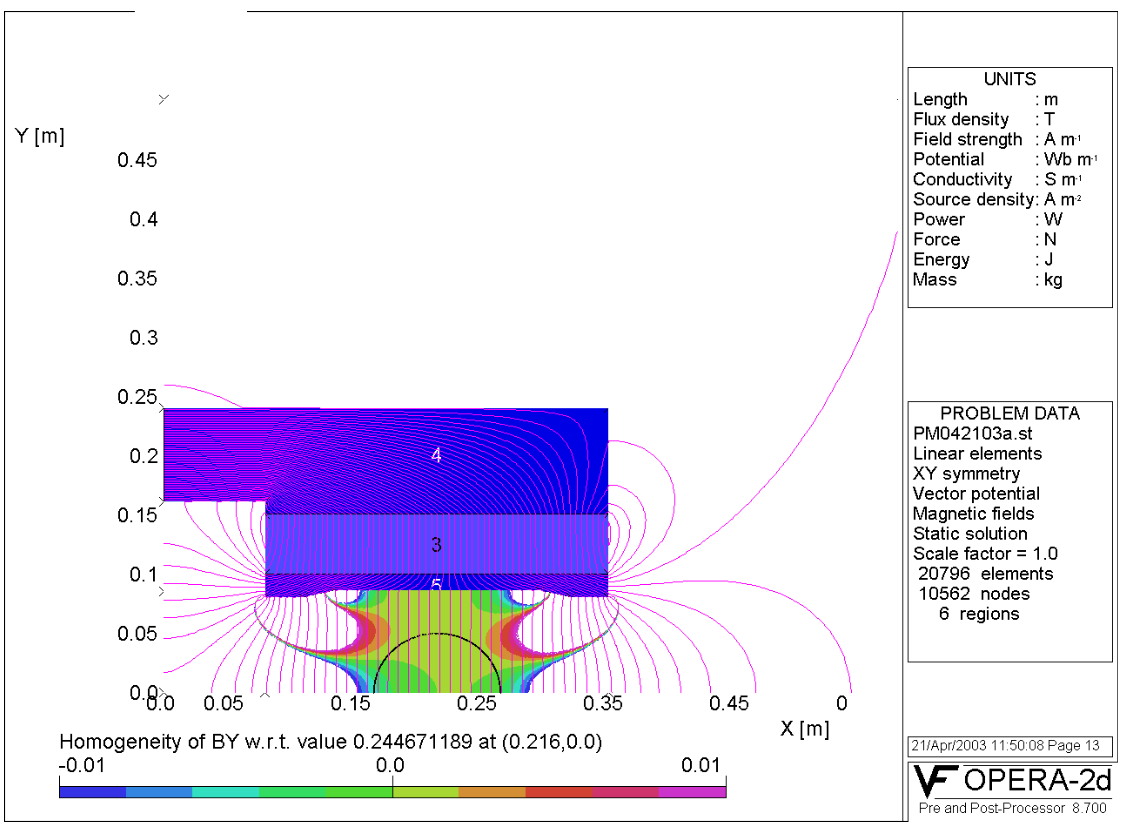

Fig. 5 Permanent magnet field homogeneity

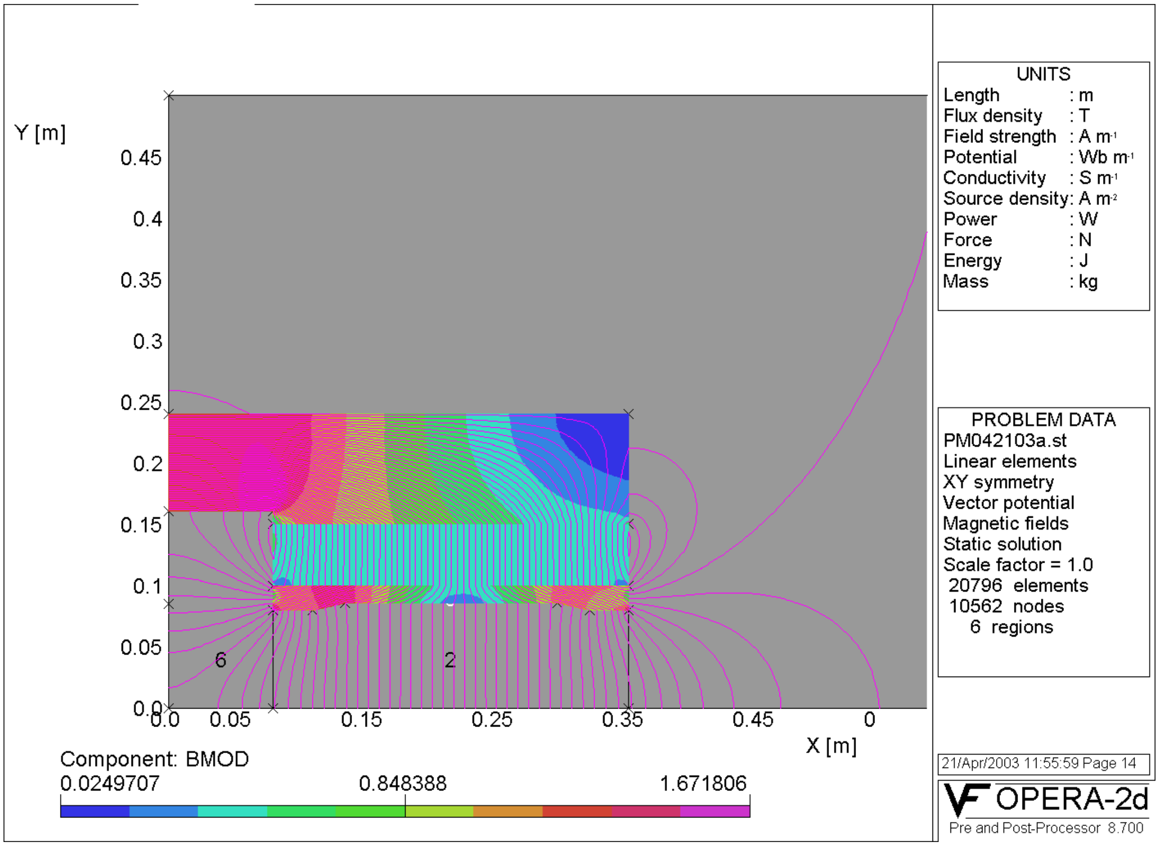

Fig. 6 Permanent magnet flux density distribution

Electromagnet 3D magnetic field analysis

3D Magnetic field calculations showed the ~ 20% lower field than for 2D geometry. The current was increased up to 257 A to compensate the influence of additional fringing fields. The cross-section of iron core top and bottom also were increased in transverse direction to avoid iron saturation effects.

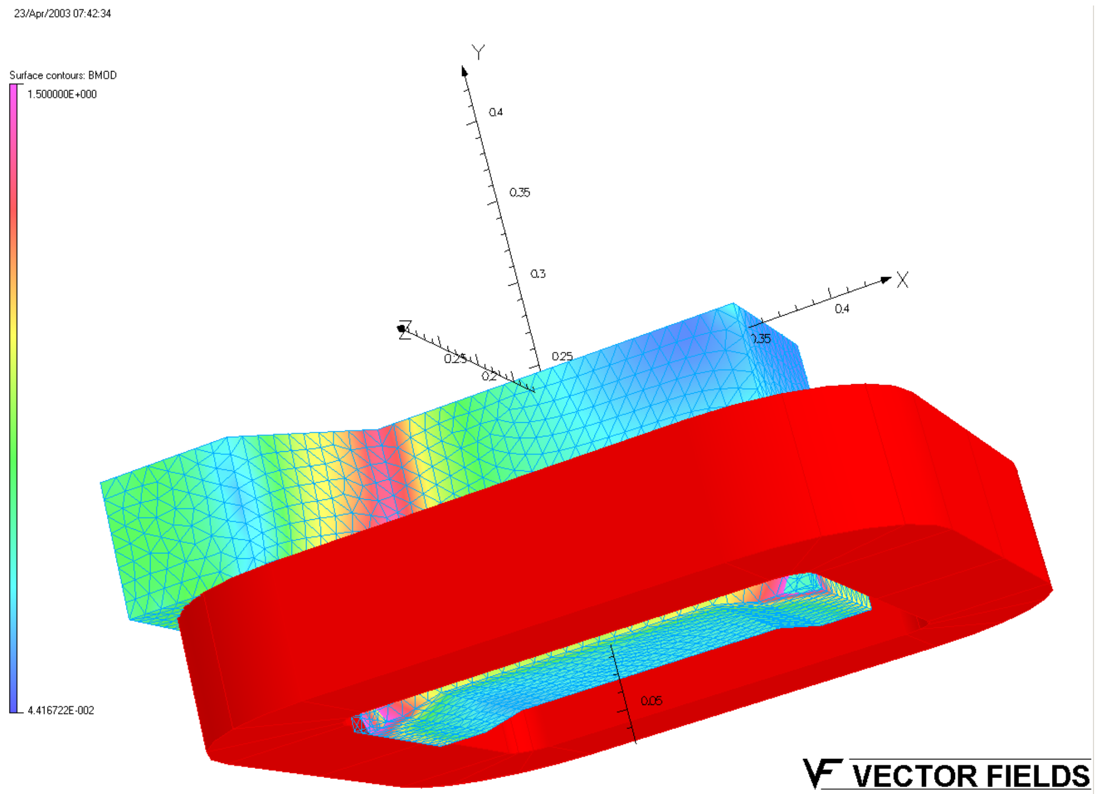

Fig. 7 Upper part of electromagnet assembly

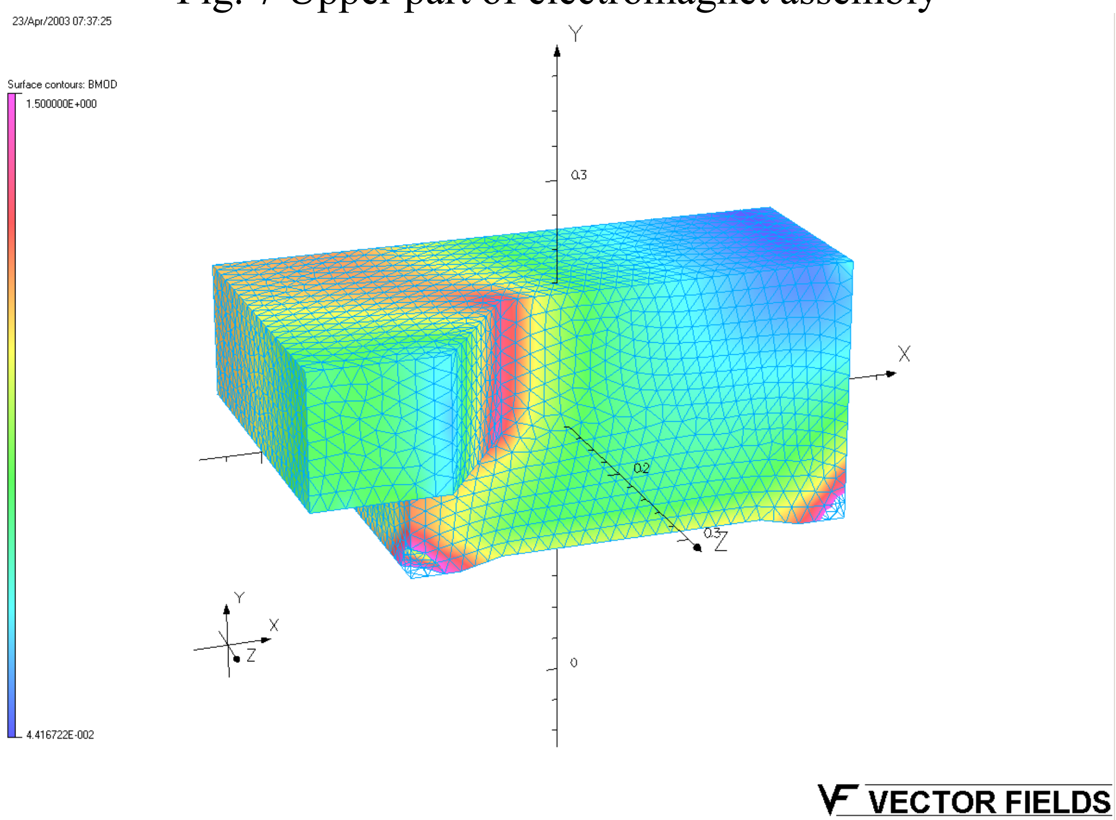

Fig. 8 Flux density distribution in the iron core

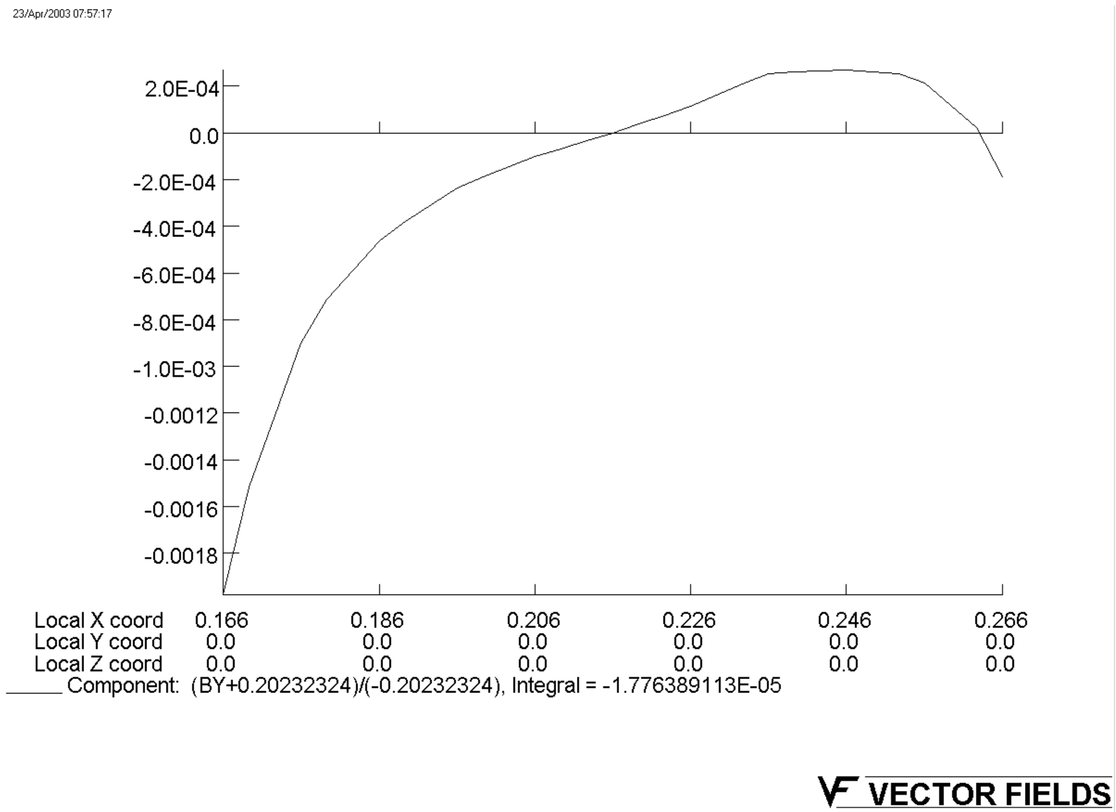

Fig. 9 Field homogeneity along the beam path

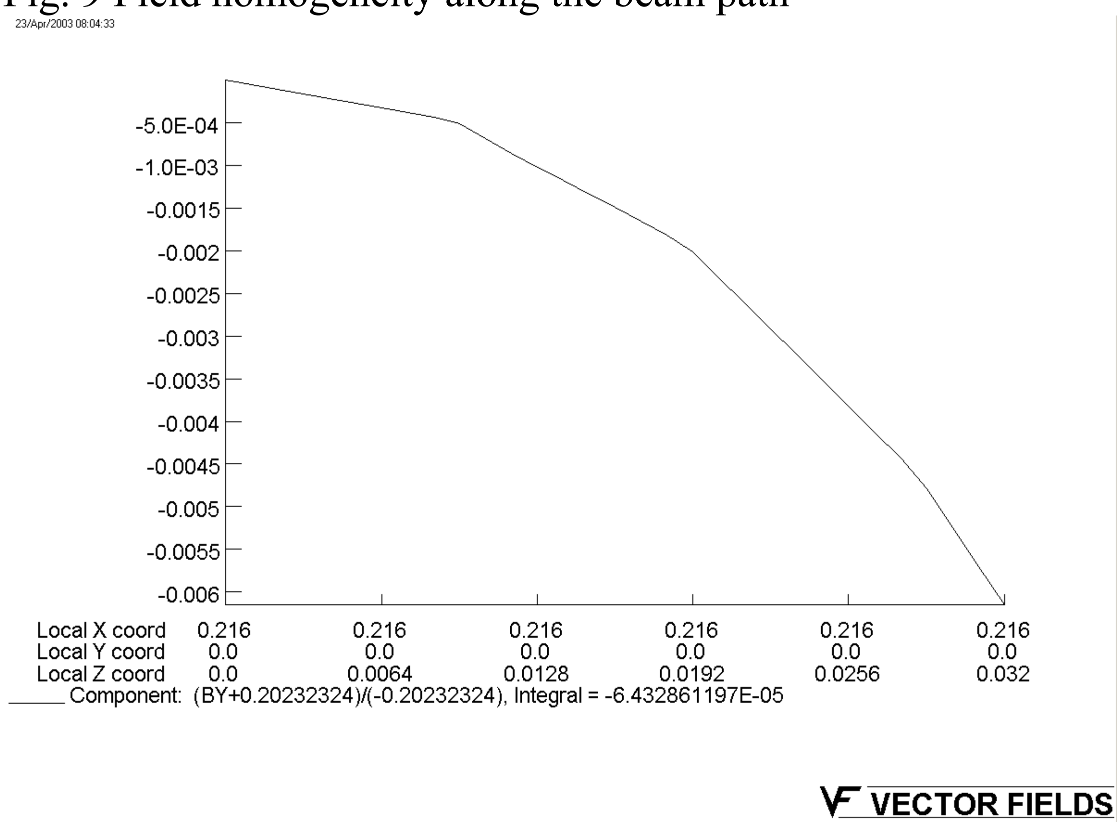

Fig. 10 Field homogeneity in transverse to the beam path direction

Permanent magnet 3D magnetic field analysis

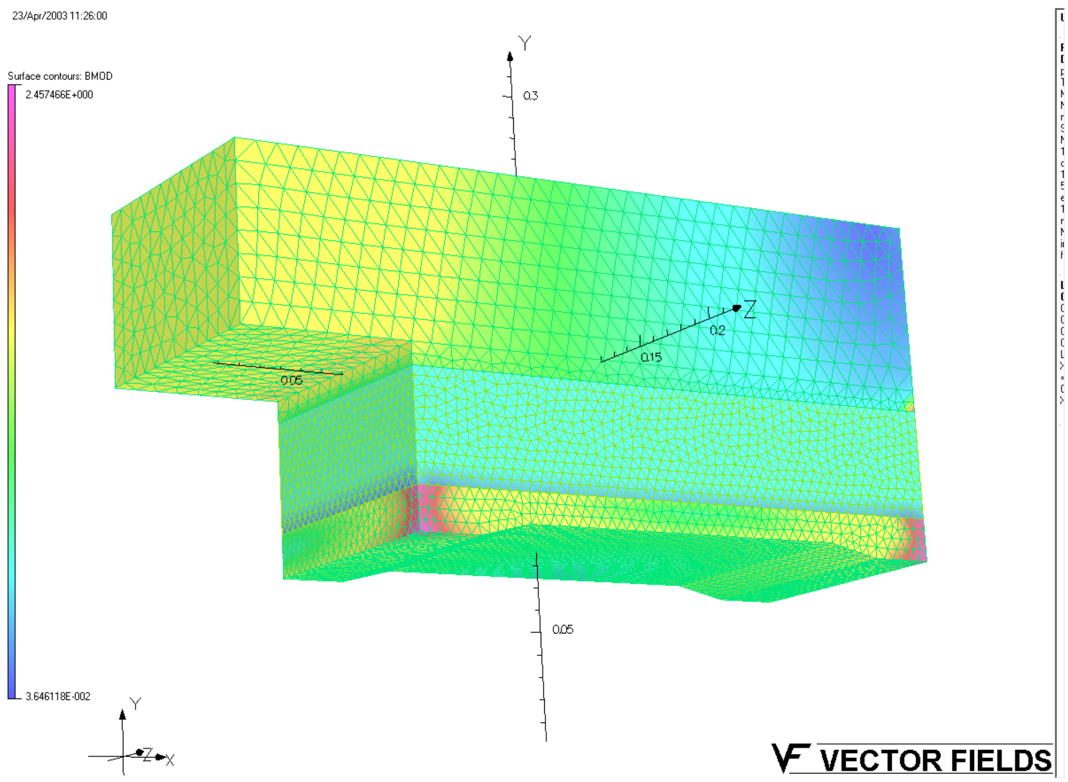

Fig. 11 Field flux density distribution

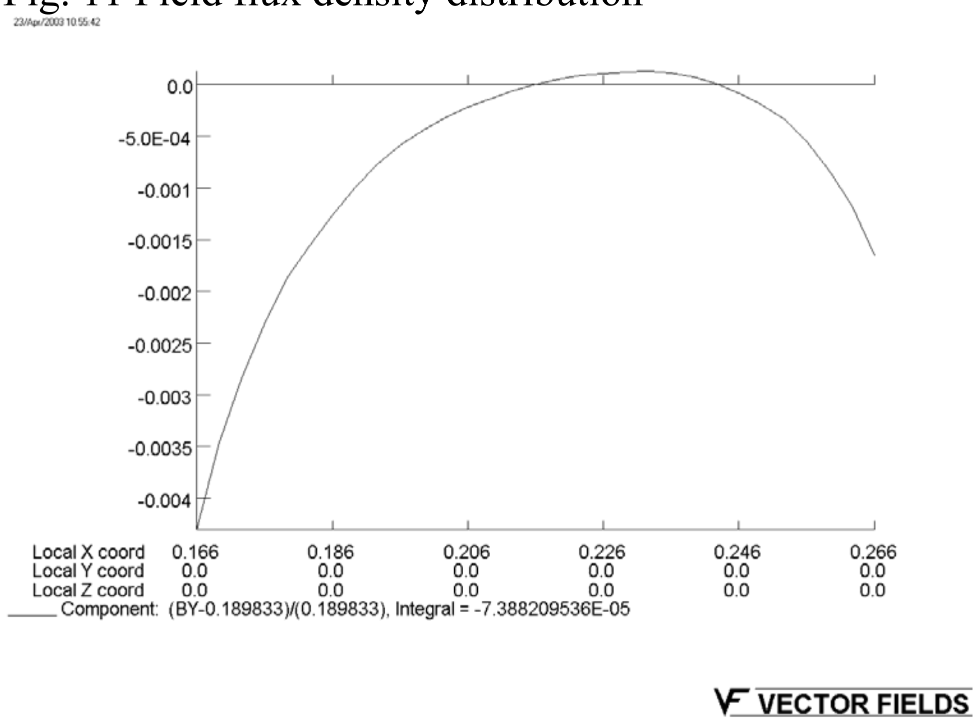

Fig. 12 Field homogeneity along the beam path

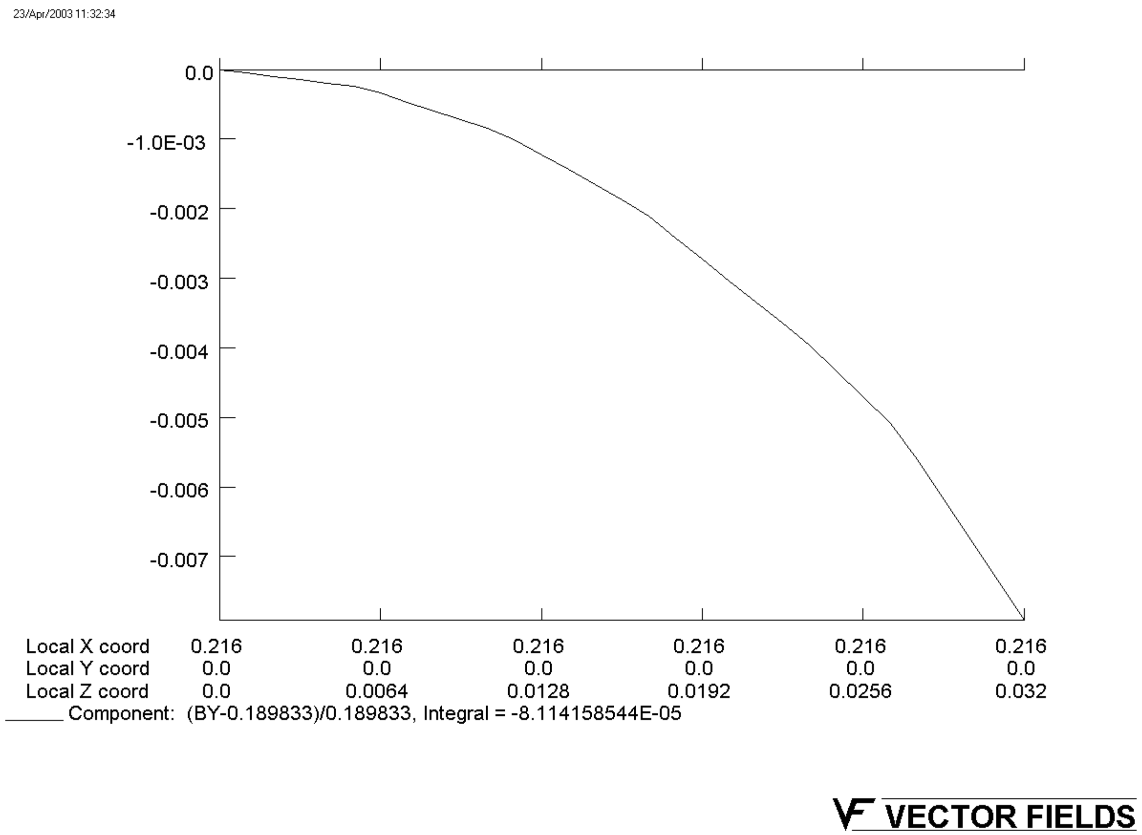

Fig. 13 Field homogeneity in transverse to the beam path direction

Summary

Both versions of magnet are visible. Some amount of design work needed to improve pole shimming especially in transverse direction. Permanent magnet calculations were made using $SmCo_5$ permanent magnet material. In the case of NeFeB permanent magnets the volume of PM material can be reduced. There are several options how to connect upper and lower magnet subassemblies and it should be clarified during design work.